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(54) IMPROVEMENTS RELATING TO OPTICAL WAVEGUIDES

(71) We, THE PLESSEY COMPANY LIMITED, a British Company of Vicarage Lane, Ilford, Essex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to optical waveguides and relates more specifically to such waveguides having optical filtering characteristics.

According to the present invention there is provided an optical waveguide comprising an elongate transparent core contained within a contiguous sheath of material having different refractive index from the core so that light is propagated along the core by total internal reflection at the interface between said core and said sheath provided the angle of incidence of light at said interface is greater than the critical angle for internal reflection to occur, in which said core comprises particles or globules of one material suspended in another material such that the core materials have the same or very similar refractive indices to light of a predetermined wavelength or narrow range of wavelengths to permit propagation thereof along said core whereas light of different wavelengths will be scattered by the core so that it impinges on the core sheath interface at an angle less than said critical angle.

In carrying out the present invention the core of the optical waveguide may comprise transparent solid particles suspended in a transparent liquid or the particles may be embodied in a transparent solidified medium. Alternatively, globules or droplets of one liquid may be suspended in a different liquid.

In cases where the waveguide core includes liquid material(s) the ends of the core may be closed by transparent (e.g. glass) windows located perpendciularly to the core axis.

Optical filtering waveguides constructed according to the present invention which are compatible with conventional forms of glass fibre waveguides may be used for filtering out light of certain wavelengths of light applied at one end of the waveguide. It thus serves as a narrow band filter.

The waveguide transmission characteristics may also be adjusted as required in response to temperature modification so that it can be employed as a temperature-tunable narrow band filter. The wavegude may conveniently be employed to detect ambient temperature by arranging that white light is applied to one end so that the colour of light emerging from the other end indicates temperature. Such use may have application in automobiles for providing dashboard indication of the engine temperature.

By way of example the present invention will now be described with reference to the drawings accompanying the provisional specification in which:

Figs. 1 and 2 show longitudinal and transverse cross-sectional views, respectively, of one embodiment of optical waveguide filter according to the present invention; and,

Figs. 3 and 4 are diagrams depicting the mode of operation of the waveguide filter of Figs. 1 and 2.

Referring to the drawings the optical waveguide filter depicted comprises a transparent glass tube 1 of circular cross section which contains a waveguide core 2. This core 2 in the present example comprises transparent particles 3 of one material which are suspended in a transparent liquid 4. The liquid and suspended particles are contained within the glass tube 1 by means of end closure glass windows 5 and 6 disposed perpendicularly to

the axis of the waveguide.

When the refractive indices of the core liquid 4 is significantly different from that of the suspended particles 3 rays of light, such as those indicated at 7 and 8 in Fig. 3 will be refracted strongly by the particles so that, as indicated, the light energy will be scattered by the rays impinging on the interface between the core 2 and tube 1 at an angle less than the critical angle for total internal refraction at said interface. When, however, the refractive indices of the liquid 4 and particles 3 are matched exactly, then no refraction at all takes place in the particles, that is to say the filter waveguide acts precisely as a conventional waveguide with a solid transparent core of a single material so that maximum transmission of light through the core 2 is obtained. This condition is demonstrated by the ray of light 9 in Fig. 4.

In those cases where near matching of refractive indices obtains, some slight scattering of light within the waveguide will take place.

Since the refractive indices of the material of the core 2 depends on the temperature, it will be appreciated that the condition of maximum transmission is also temperature dependent provided of course that the refractive indices of the two core materials do not vary with tempearture so that the ratio between the indices remains unchanged.

From the foregoing it will readily be appreciated that the waveguide temperature could be selected so as to tune the waveguide whereby it produces maximum transmission of light of a certain wavelength or narrow band of wavelengths. Conversely, the colour of light emerging from the waveguide when white light is introduced at the input end of the waveguide, could provide an indication of the ambient temperature of the waveguide. In one specific application of the waveguide for temperature indication purposes, the waveguide could be located in good heat exchange relationship with an automobile engine. Light from a tungsten filament lamp, for example, may be transmitted to the input end of the waveguide through a conventional fibre optic light guide and light emerging from the wavegude may be conveyed by a second fibre optic light guide to the instrument panel so as to provide a direct visual indication of engine temperature.

Although in the specific embodiment described above with reference to the accompanying drawings a glass tube 1 is provided and the core 2 comprises particles 3 suspended on a transparent liquid 4, it should be understood that various modifications are contemplated. For example, the core 2 may be solid in which case the glass windows 5 and 6 may be omitted or the glass tube could be flexible by providing a small diameter glass capillary tube or a plastics tube, or still further the waveguide tube may be rigid but pre-bent so that the guiding characteristics of the waveguide guide the light around the bends.

In one example of a filtering optical waveguide according to the invention a tube of vitreous silica is filled with granules of sodum borosilicate glass particles which are immersed in trichloroethylene. This waveguide will filter transmitted light to give a transmission band at 600nm (red light) at a temperature of 30°C, and at 400nm (purple light) at a temperature of 50°C. The variety of solid particles and liquids that could be used is so large (particularly when liquid mixtures are used) that a filter may readily be designed to cover much wider temperature ranges.

WHAT WE CLAIM IS:—

1. An optical waveguide comprising an elongate transparent core contained within a contiguous sheath of material having different refractive index from the core so that light is propagated along the core by total internal reflection at the interface between said core and said sheath provided the angle of incidence of light at said interface is greater than the critical angle for internal reflection to occur, in which said core comprises particles or globules of one material suspended in another material such that the core materials have the same or very similar refractive indices to light of a predetermined wavelength or narrow range of wavelengths, to permit propagation thereof along said core, whereas light of different wavelengths will be scattered by the core so that it impinges on the core sheath interface at an angle less than said critical angle.

2. An optical waveguide as claimed in claim 1 in which the core of the optical waveguide comprises transparent solid particles suspended in a transparent liquid.

3. An optical waveguide as claimed in claim 1 in which the core of the optical waveguide comprises transparent solid particles embodied in a transparent solidified medium.

4. An optical waveguide as claimed in claim 1 in which the core of the optical waveguide comprises transparent globules or droplets of one liquid suspended in a different transparent liquid.

5. An optical waveguide as claimed in claim 2 or claim 4 in which the ends of the core are closed by transparent windows located perpendicular to the core axis.

6. An optical waveguide as claimed in claim 5 when dependent on claim 2 in

which the transparent solid particles are sodium borosilicate glass particles and in which the transparent liquid is trichloroethylene.

7. A temperature sensing device including an optical waveguide as claimed in any one of the preceding claims in which the combination of the particles or globules of the one material and the other material are temperature sensitive.

8. An optical waveguide substantially as described with reference to the drawings accompanying the provisional specification.

9. A temperature sensing device substantially as described with reference to the drawings accompanying the provisional specification.

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1558404 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale

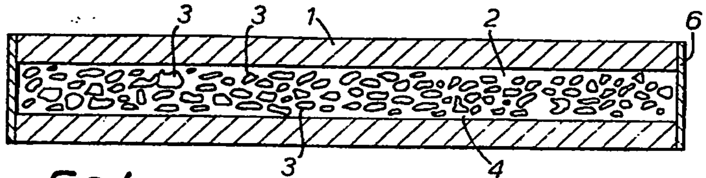

FIG. 1.

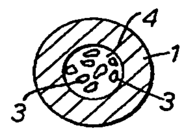

FIG. 2.

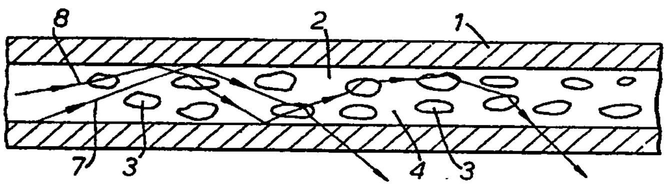

FIG. 3.

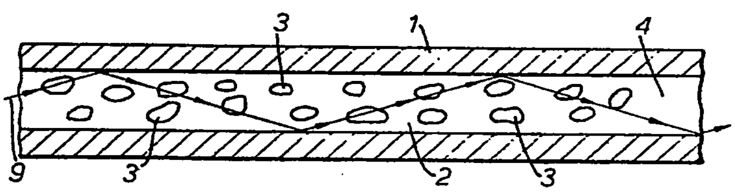

FIG. 4.